

Nature of the Quantum Ferromagnetic Phase Transition

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Phase transitions can be either

- **first order**: An observable (“order parameter”) changes **discontinuously** or
- **second order**: The order parameter changes **continuously**

Ferromagnetic transitions in zero field are normally **second order**

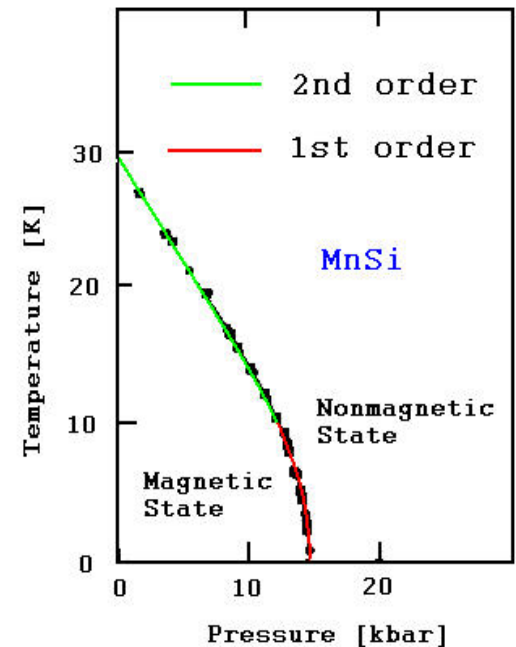
Observation: In ferromagnets where the transition temperature can be tuned to zero, the transition often turns **first order** at very low temperatures

Examples: MnSi (see figure), UGe₂, ZrZn₂

Theory: A theory developed by the PIs and their collaborators shows:

- The ferromagnetic transition at very low temperatures is generically first order in clean materials, but second order in disordered ones
- The physical mechanism is the same as the one for a first order transitions in nematic liquid crystals, and closely related to the Coleman-Weinberg mechanism for mass generation in particle physics

Phase diagram of MnSi
(after Pfleiderer et al 1997)



Conclusion: The theory not only explains the observations, it also illustrates amazing analogies between different fields of condensed matter physics, and even between condensed matter physics and particle physics

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Education and Development of Human Resources:

Personnel involved with projects supported by these two grants include,

- **Qi Li**, current graduate student
- **Annemarie Rey**, current graduate student and Staff Scientist, NIST
- **Jörg Rollbühler**, current postdoc
- **Sharon Sessions**, former graduate student, currently Vis. Asst. Prof., New Mexico Tech
- **Ryan Shannon**, current graduate student
- **Ken Snyders**, current graduate student and Staff Scientist, NIST
- **Sumanta Tewari**, current postdoc
- **Thomas Vojta**, former postdoc, currently Asst. Prof., Univ. of Missouri
- **Lubo Zhou**, current graduate student

Outreach and Synergistic Activities:

- The PIs, together with T. Vojta, served as scientific coordinators for an international workshop at the MPIKS Dresden that drew roughly 100 participants



- PI Belitz served as organizer of a Mini-Colloquium at the European Physical Society Meeting in Prague, Czech Republic, in July 2004